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(54) **Card readers**

(57) A security document includes a security thread which carries a code, constituted by magnetisable and non-magnetisable portions. The code is a multiple bit code. The position of the thread and its orientation relative to a reading machine can vary within wide limits. The code is read by passing the document under a head which applies a magnetic field to the thread and thereafter the thread is passed under an array 11 of magnetic reading heads which are scanned to provide a repetitive time varying signal representing the code on that part of the thread which has been read. The bits may be read in parallel or sequentially. An array of amplifiers 13 temporarily store the peak voltages derived by the reading heads. A multiplexer 14 sequentially scans the stored signals to derive a time varying signal representative of the binary code.

FIG. 2.

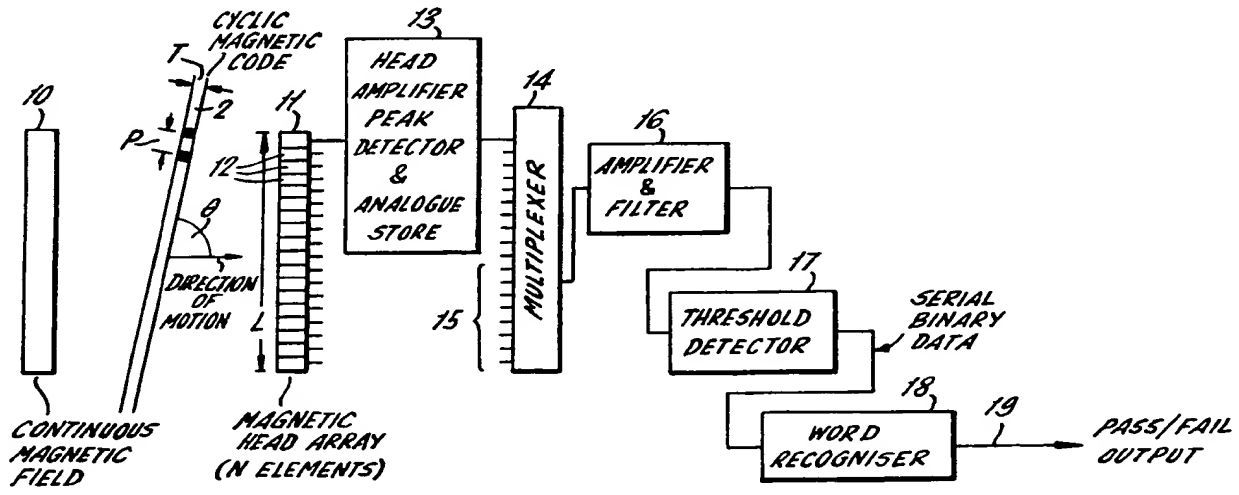

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FIG. 1.

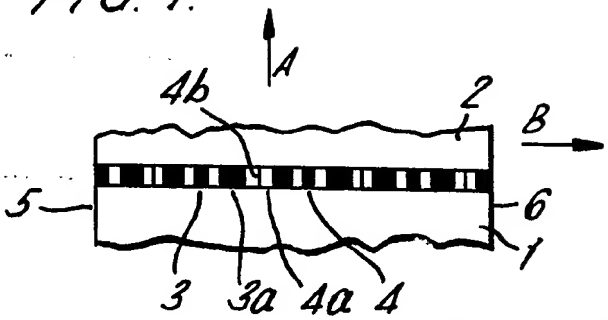


FIG. 2.

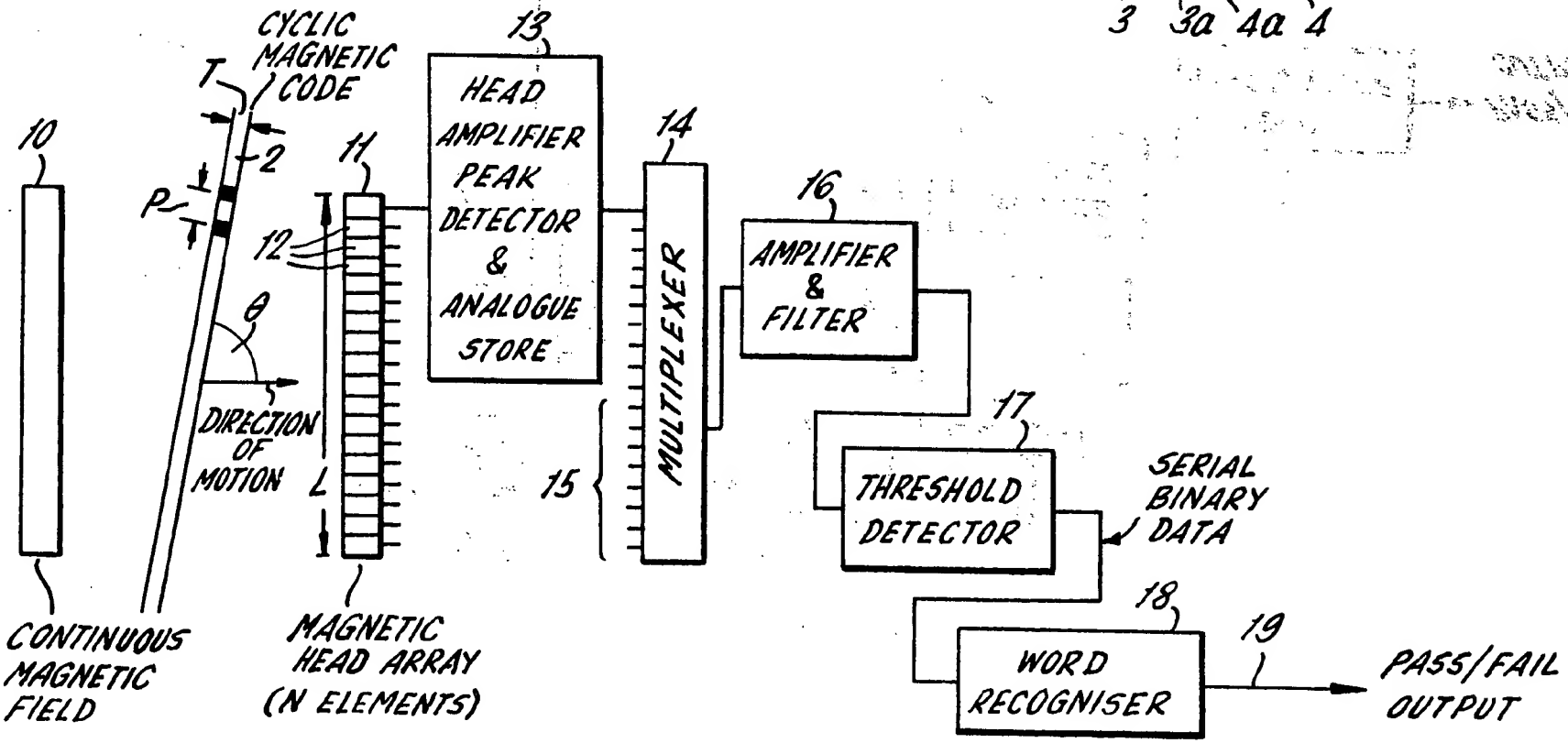
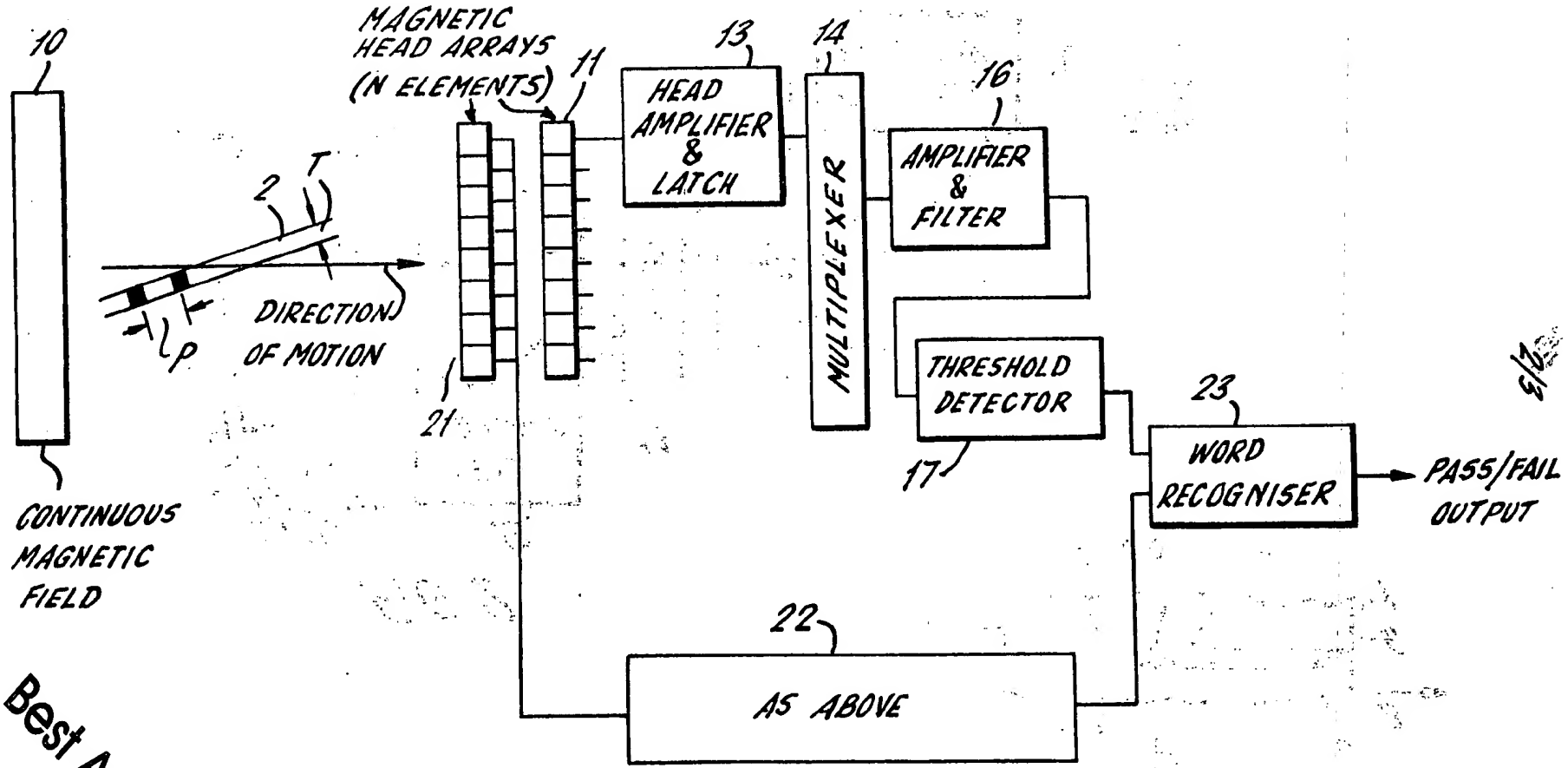


FIG. 3.



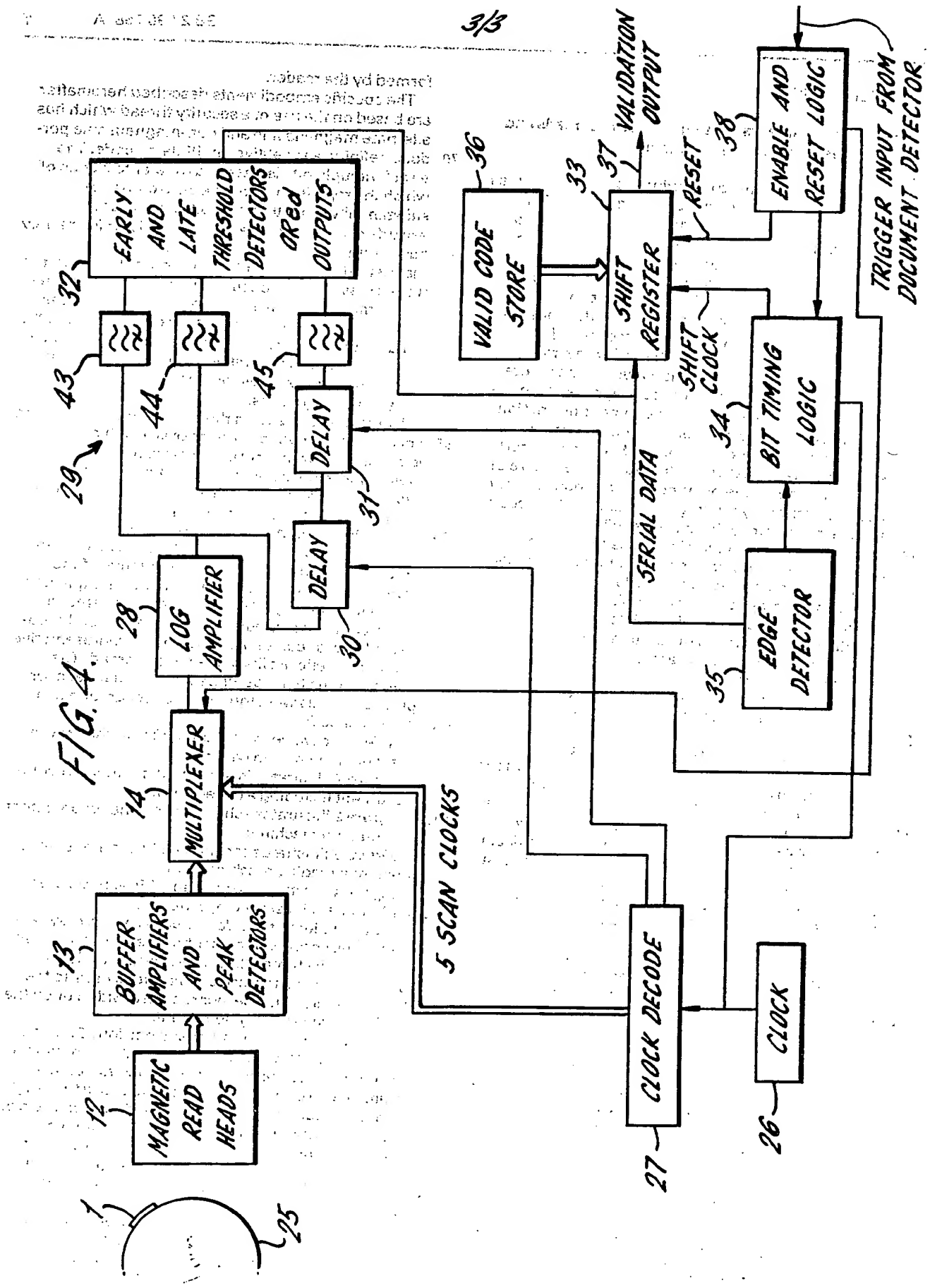

1
25
MAGNETIC READ HEADS
12
BUFFER AMPLIFIERS AND PEAK DETECTORS
13
MULTIPLEXER
14
5 SCAN CLOCKS
LOG AMPLIFIER
28
29
DELAY
30
DELAY
31
EARLY AND LATE THRESHOLD DETECTORS ORed OUTPUTS
32
43
44
45
CLOCK DECODE
27
CLOCK
26
VALID CODE STORE
36
SHIFT REGISTER
33
VALIDATION OUTPUT
37
RESET
SERIAL DATA
SHIFT CLOCK
BIT TIMING LOGIC
34
EDGE DETECTOR
35
ENABLE AND RESET LOGIC
38
TRIGGER INPUT FROM DOCUMENT DETECTOR

FIG. 4.

SPECIFICATION

Security documents including security threads and machines for interrogating them

This invention relates to security documents, such as banknotes and other currency documents which include a security thread (which phrase includes a narrow strip) which defines a multibit code and to a machine for reading that code.

There have been many proposals for the incorporation of a security thread in a document so as to enable by means of a reading machine the verification of the authenticity of the document or of information presented on it. The code may, for example, relate to the nominal value of a banknote or a serial number printed on it or might relate to the name or identification number or other information on a security document. For the purposes of the present invention the relationship between the code which is represented by the thread and the nature of or information on the document is not important, the invention primarily relating to the nature of the code and the manner in which it can be reliably read notwithstanding variation in the position of the thread on the document or, within limits, the manner in which it is presented to the reader.

It has been proposed, for example in the specification of British Patent No. 1127043, to provide security paper which includes a thread which has a discontinuous magnetic coating. It is also proposed that a magnetic security device such as a thread may be read by means of a preliminary magnetisation of the device and the subsequent detection of the magnetisation.

One object of the present invention is to arrange the coding and a reader of the security strip or thread so that within quite wide limits variation in the orientation of the thread relative to the reader or the reading of only part of the thread does not prevent the proper verification of the existence of a particular code carried by the thread. Although it is possible at least for some forms of security document to arrange a reader so that the document is always presented with the same orientation to a reading device, the present invention is concerned with the problems arising when such predetermined orientation of the security thread is, for one reason or another, either impossible or inappropriate. For example, it may be desirable, to facilitate the stacking of documents which incorporate a thread of substantial thickness to vary the position of the security thread or strip relative to the document. It may be necessary, for the purpose of achieving high speed sorting, to accommodate documents which are skewed relative to the reader. Moreover, the document which is to be read might be one of a large quantity of used security documents which cannot conveniently be uniformly presented to a reader. For these and other reasons the present invention is intended to provide, at least in its specific embodiments, for the reading of coded thread of which the position or orientation or both may be varied or variable in an unknown manner relative to the reader without preventing the verification which is performed by the reader.

The specific embodiments described hereinafter are based on the use of a security thread which has alternate magnetisable and non-magnetisable portions defining a repetitive, multiple bit code. The term "multiple bit" is intended to refer to a code of which the repetition along the strip consists of substantially more than two bit cells, so as to exclude such arrangements as threads which merely have alternately magnetisable and non-magnetisable portions of equal length. Although the thread may be positioned or oriented in a predetermined manner relative to the document, such positioning or orientation is not necessary and one of the features of the embodiments to be described is their ability to read a thread reliably notwithstanding a considerable skew angle of the thread relative to an array of reading heads.

The reader is based on the provision of at least one linear array of magnetic heads of which the spacing is generally commensurate (as hereinafter explained) with the spacing of the bit cells on the security thread, the storage, which may be temporary, of signals picked up by the heads and the sequential scanning of the heads so as to produce a signal which represents in serial manner a repetitive time varying output signal representative of the magnetic coding of the thread. As will be explained hereinafter, the signal may be filtered to remove high frequency components and subsequently processed to produce a binary waveform representative of the magnetic profile of the coded thread. The embodiments to be described include a means for processing this waveform for the recognition of a particular code.

Reference wil be made hereinafter to the accompanying drawings, in which:-

Figure 1 illustrates in simplified manner a security document including a coded strip;

Figure 2 illustrates schematically one embodiment of a reading machine;

Figure 3 illustrates schematically another embodiment of a reading machine; and

Figure 4 illustrates a more specific version of an embodiment illustrated by Figure 2.

Figure 1 illustrates a document 1, which may be a banknote, security document or the like, incorporating a security thread 2. A code may be made by printing with an appropriate magnetic ink into the thread 2 which may be incorporated within or on the surface of the security document.

The code comprises magnetic portions 3, constituted by the aforementioned ink, and non-magnetic portions 4. The portions are arranged to define a multiple bit code which is repetitive along the length of the thread. It will be appreciated that each cycle of the code occupies a number of bit cells but that where there are adjacent cells representing the same binary value either the magnetisable portion or the non-magnetisabl portion, according to the binary value, will extend over two or more bit cells; for example, the non-magnetisable portion 4*a* extends over two bit cells (separated by the notional line 4*b*) and the portion 3*a* likewise extends over two bit cells. The code may, for example, be an ight bit

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code of which three bits constitute a preamble and of which five bits constitute a particular digital word.

In Figure 1 the thread 2 is shown at right angles to the edges 5 and 6 of the document 1. Moreover, the embodiments of the reader are intended to read the code as it is moved in a direction generally indicated by the arrow A or by the arrow B. However, it is important to note that not only may the directions A and B not be perpendicular to or parallel to the direction of the strip but that furthermore the position or orientation of the thread on the document may be varied within very wide limits without affecting the operation of the respective readers shown in Figure 2 and Figure 3 respectively. Moreover, the embodiments of reader described with reference to those figures are intended to be capable of reading the thread reliably notwithstanding some variation in the length of the thread owing to the stretching or shrinking of the document on which the thread is disposed.

Figure 2 illustrates one embodiment of a reader, which is intended to read the thread 2 as it is presented generally broadside to a reading head. Figure 2 shows the thread 2 disposed at an angle θ to its direction of motion. For the ease of explanation hereinafter, the pitch between code cells on the thread is represented by P and the breadth of the thread is represented by T.

The readers shown in Figure 2 may be arranged to read the thread 2 as the document which carries it is passed either mechanically or manually past an array of reading heads. Before the thread is read, it is passed through a uniform magnetic field, provided by a magnetic assembly 10, and then moved past a linear array 11 of magnetic heads 12.

In this embodiment of the invention the reader is intended to read the code cells on the thread in parallel and to derive by means of sequential scanning of stores containing the signals picked up by the heads 12 a serial signal representing the magnetic code. The array of magnetic heads is such that the maximum pitch between the heads is approximately equal to $P \sin\theta$. In practice the minimum value of θ is a function of the code pitch P and the thread's thickness T. It will be apparent that the length of the array 11 need not be equal to or greater than the length of the coded thread 2, it being sufficient that the length of the array 11 is not less than $NP \sin\theta$ where N is the number of bits in the repeated code.

The actual pitch between the heads 12 should not be greater than the pitch P between adjacent bit cells. Preferably, to ensure accurate recognition the pitch between heads 12 is substantially less than P. For example, the pitch between heads may be 0.5 P and accordingly for large values of θ, when the thread is presented almost broadside to the array 11, the magnetic information is sampled at twice the bit spacing on the thread.

Each magnetic head 12 is coupled to a respective one of an array of amplifiers 13 each including a detector that includes a temporary storage device such as a capacitor so that a voltage equivalent to the peak signal obtained by the head is stored on the capacitor.

For sampling the stores included within the amplifiers 13 is a multiplexer or sequential scanner 14 of which the inputs 15 are connected one to each amplifier 13. This multiplexer samples in a repetitive sequential scanning sequence the stored signals and produces thereby a repetitive time varying output signal which represents the magnetic profile of the thread and accordingly the binary coding on it. This signal is fed to an amplifier 16 which includes a low-pass filter for the removal of high frequency components of the input waveform. The output of the amplifier 16 is fed to a threshold detector 17, which ignores spurious signals of low amplitude and which provides an output of a serial stream of binary bits corresponding to the bit pattern on that section of the thread which is read by the array 11.

The position of the thread 2 relative to the array being indeterminate, the output of the threshold detector 17 may represent repetitively any section of the coding on the thread 2. In order to determine whether a particular multiple bit code is present on the thread 2, it is convenient to employ a code which comprises a distinctive preamble, consisting of some suitable multiplicity of bits, followed by a data word which represents the code which should be retrieved. A word recogniser which receives the output of the detector 17, may be arranged to clock the binary waveform into a shift register until predetermined stages in the register simultaneously detect the presence of a set of bits corresponding to the preamble. The data required may then be extracted from the sequence of bits following that preamble.

An output signal from the word recogniser is fed out on a line 19.

In practice there may be a discontinuity in the serial output waveform arising from the fact that the first and last heads 12 in the array 11 may sense different parts of the repetitive code, the distance between the heads being in general not equal to a multiple of the length of each cycle of the code on the thread 2. In general, provided that the length of the array 11 is sufficient to extend over a plurality of cycles of the code, this discontinuity is of no importance.

Figure 3 illustrates an embodiment suitable for reading the thread 2 if it be presented so that the bits on it are read sequentially rather than substantially parallel as in the embodiment of Figure 2. In Figure 3 the various components correspond generally to the similarly numbered components in Figure 1. However, in the embodiment shown in Figure 3, there are two parallel arrays 11 and 21 of magnetic heads. Each is associated with a similar processing circuit, which is shown as comprising the components 13 to 17 for the array 11 but is shown as comprising the channel 22 for the array of heads 21. The arrays 11 and 21 are staggered in their mutual direction.

In the operation of the embodiment shown in Figure 3, the document is passed by the assembly 10 so as to magnetise the magnetisable portions of the thread 2, the document being moved past the arrays 21 and 11 such that the thread 2 is generally perpendicular to each of the arrays 11 and 21. As explained hereinbefore, the angle at which the

thread 2 is presented may be anywhere within quite a wide range.

In this embodiment of the invention the head amplifiers 13 include a respective latch. In general, only a few of the heads 11 or 21 will respond to the magnetisable portions. The signal output from each head is amplified by the amplifier 13 and its leading edge sets the respective latch, the latch being cleared by the trailing edge of the signal which sets the latch. It will be understood that the reading of a magnetic portion by a head element normally produces an initial short pulse followed by a short pulse of opposite polarity; the amplifier 13 includes appropriate circuitry such that the latch is set by the initial pulse and reset by the subsequent pulse.

The latches of all the head amplifiers 13 are strobed or scanned at a suitable, high, clock rate by the multiplexer 14. This scanning produces, to a different but proportional time scale, a serial waveform which, as in the first embodiment of the invention, represents the coding along the thread 2. This serial waveform is passed through an amplifier and low-pass filter 16 and a threshold detector 17, similar to the corresponding components in Figure 2, and is fed to a word recogniser 23 arranged in a manner similar to that of the word recogniser 18 in Figure 2.

Owing to the possible obliquity of the thread 2 relative to a direction perpendicular to an array 11, the setting and resetting of the latches of adjacent heads in an array 11 may not, for particular values of the angle of presentation of the thead, properly represent the coding on the thread. In order to eliminate this possibility, the channel 22 coupled to the heads 21 produces likewise a binary progression which is received by the word recogniser 23. The recogniser 23 has an input OR gate which combines the outputs of the threshold detectors in the two channels.

Figure 4 illustrates in more detail a preferred embodiment already schematically illustrated by Figure 2. In Figure 4, the document 1 is shown as carried on a drum 25 (in any convenient manner) for passage adjacent a set (in this embodiment 16) of magnetic read heads 12, which feed respective buffer amplifiers and peak detectors 13. The outputs of the sixteen outputs therefrom are fed to the multiplexer 14 the addressing of which is controlled by a master clock 26 *via* a clock decode circuit 27.

Each successive output from the multiplexer 14 is amplified by a logarithmic amplifier 28 which feeds a threshold detector circuit 29. In this circuit, a range for valid detection of the output of the amplifier 28 at a particular time is set by the output of the amplifier 28 taken slightly earlier and slightly lat r than the particular time. For this purpos the output of the amplifier 28 is fed through two delays 30 and 31 in tandem and a comparator circuit 32 rec ives the undelayed, once delayed and twice delayed output of the amplifier 28 *via* respective low-pass filters 43, 44 and 45. The comparator circuit 32 treats the first delayed output (obtained from the output of the delay 30) as the output of interest and the undelayed and twice delayed outputs as referenc signals for threshold detection. The delays 30 and 31 may be switched delays controlled by the clock decode circuit 27.

The output from the circuit 32 is in serial form and is clocked into a shift register 33. Timing for this purpose is obtained from bit timing logic 34 controlled from the master clock 26 and adjusted by means of an edge detector 35 which receives the output of the circuit 32.

The contents of the shift register 33 are compared with the contents of a store 36 which holds the valid code which should be detected on the document. If there is a match, the shift register signals at an output terminal 37.

It is preferable to provide enable and reset logic 38 which may be triggered by a document detector immediately before the document is read by the heads 12 and which resets the shift register 33 and enables the bit timing logic 34 to provide a shift clock to the shift register 33. The logic 38 may also provide an enabling input to the multiplexer 14.

CLAIMS

1. A machine which is capable of interrogating a multiple bit code carried by a document which includes a thread composed of alternate magnetisable and non-magnetisable portions defining the said code repetitively along the thread, the cycle of repetition being substantially greater than two bit cells, the machine being arranged to apply a magnetic field to the region of the thread and thereafter to read the coding of at least part of the thread as the document moves relative to a reading device, the reading device comprising at least one linear array of magnetic heads, a temporary store for storing a representation of each magentisable portion sensed by the respective head and means for sequentially scanning the stores so as to produce a repetitive time varying signal representing the variation of magentisation along at least part of the thread.

2. A machine according to claim 1, including means responsive to the time varying signal to recognise a predetermined code pattern therein.

3. A machine according to claim 2 in which the means for recognising a particular code pattern includes means for converting the time varying signal into a serial binary signal, a shift register arranged to receive the serial binary signal and means for recognising the occurrence of a particular sequence of bits in a particular set of stages of the register.

4. A machine according to any of claims 1 to 3, arranged to read the thread as it is presented generally broadside to the said array of heads.

5. A machine according to claim 4 in which each said store comprises means for storing an analogu of a peak signal detected by the respective head.

6. A machine according to any of claims 1 to 3, arrang d to read th said thr ad as it is presented gen rally perpendicular to the array of heads so that the magnetisabl portions are read substantially in sequ nce, each store comprising means set and reset as each magnetised portion is read by a respective head.

7. A machin according to claim 6, further com-

prising a second array of heads parallel to but staggered with respect to the first-mentioned array, and including respective means for sequentially scanning stores associated with the heads in the second array to produce a repetitive time varying signal representing the variation of magnetisation along at least part of the thread.

8. A machine according to claim 3 and claim 7, comprising means for recognising a predetermined code pattern in either of the time varying signals produced by the scanning of the stores associated with the first and second arrays of heads.

9. A document as set forth in claim 1 and adapted for reading by a machine according to claim 1.

10. A machine substantially as hereinbefore described with reference to Figure 2 or Figure 3 of the accompanying drawings.

11. A document substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

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